# §15. Optimization of ICRF Heating

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In the 3rd cycle of LHD experiment, ICRF heating was performed using helium plasma with minority hydrogen ion. The spectroscopic apparatuses are installed at the vacuum ports adjacent to the ICRF antenna to monitor the intensity of Hα (656.3nm) and HeI (587.6nm). The ratio Hα/HeI is not the ratio, $n_H/(n_H + n_{He})$, but it was a good indicator to optimize the ICRF heating. As described in this annual report (April 1999-March 2000, Ion and electron heating in ICRF heated plasma), ion heating and electron heating were observed. Total absorbed power, $P_{abs}$ can be deduced from the change of the slope of the plasma stored energy at the time of ICRF turn-off. Injected ICRF heating power, $P_{ICH}$ was measured with directional coupler on coaxial line. The relation between the heating efficiency, $P_{abs}/P_{ICH}$ and the ratio Hα/HeI was investigated in the each case of electron heating and ion heating.

## 1 In case of ion heating

Figure 1-(a), (b) and (c) shows the relation between the heating efficiency and the ratio Hα/HeI in the case of ion heating i.e. $B_0$=2.893 T, $B_0$=2.75 T and $B_0$=2.5 T with the fixed applied frequency of f=38.47 MHz, respectively. Plots are distinguished by different symbols for several kinds of line averaged electron density. As shown in Fig. 1-(a) in the case of $B_0$=2.893 T there seems to be some relation between the heating efficiency and the ratio Hα/HeI and the heating efficiency reaches to about 80% around Hα/HeI = 0.8 . In the case of $B_0$=2.75 T the minority ion cyclotron resonance layer is located near the saddle point, and there is maximum in the heating efficiency (80%) around Hα/HeI = 1 . In the case of $B_0$=2.5 T the cyclotron resonance layer is across the magnetic axis, but as shown in Fig. 1-(c) it was found that the heating efficiency is not so large. The high power ICRF heating ( > 1 MW ) and long pulse ICRF heating ( >1 min.) was conducted in the case that the magnetic field strength at axis is $B_0$=2.75 T and the applied frequency is f=38.47 MHz, and succeeded by adjusting the ratio Hα/HeI with gas-puffing.

## 2 In case of electron heating

Figure 2 shows the relation between the heating efficiency and the ratio Hα/HeI in the case of electron heating i.e. $B_0$=2.75 T and f=28.4 MHz. The series of heating experiments was carried out at the line averaged electron density, $\overline{n_e}$ of 0.5 to $1.0\times10^{19}$ $m^{-3}$. The electron heating efficiency increases with the ratio of Hα/HeI.

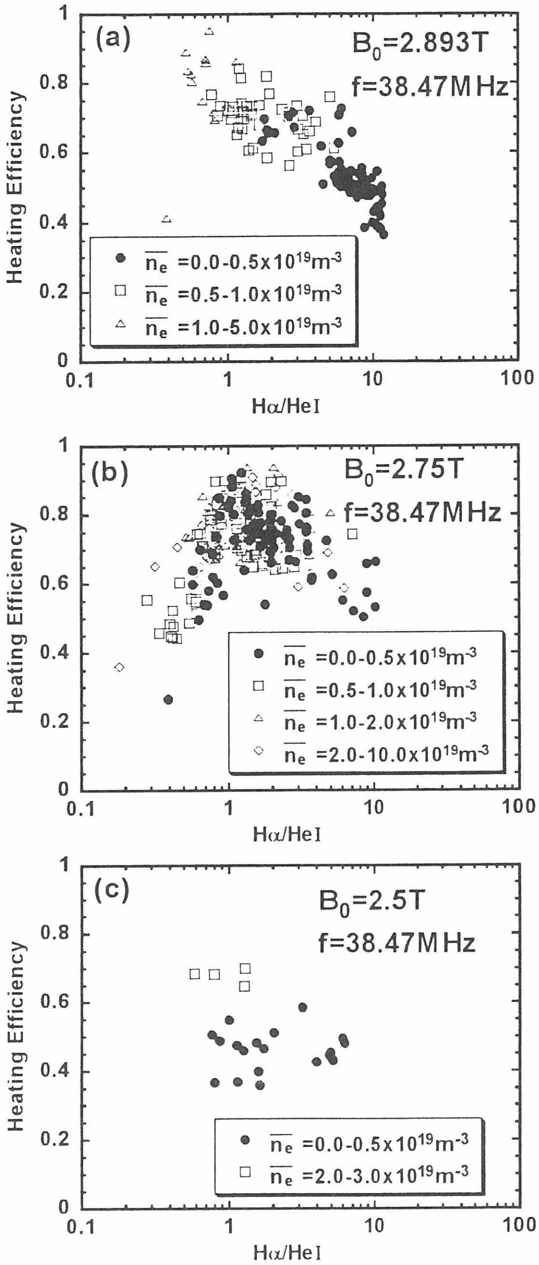


Fig. 1 The relation between the heating efficiency and the ratio Hα/HeI in ion heating.

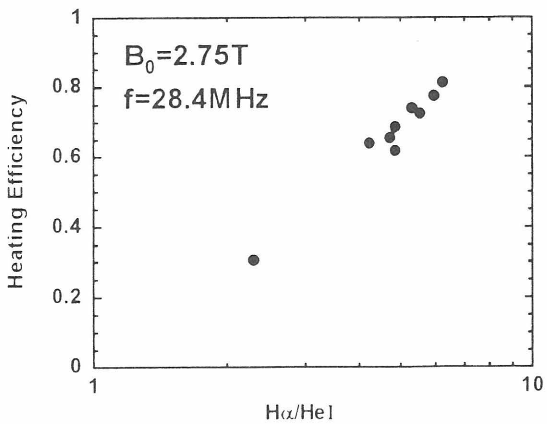


Fig. 2 The relation between the heating efficiency and the ratio Hα/HeI in electron heating.